AMENDMENTS TO THE SPECIFICATION

Please replace paragraphs of the specification with the following amended paragraphs:

[0033] Apparatus and methods for the imprinting an embossable film disposed above a substrate are described. By way of example only, embodiments of an imprint embossing system are described with respect to a disk substrate. However, it may be appreciated by one of skill in the art that embodiments of an imprint embossing system may be easily adapted for substrates that vary in shape and size (e.g., square, rectangular), for the production of different types of substrates discussed above. Embodiments of an imprinting system described herein may be used for imprinting embossable films with nano-imprint lithography techniques. Alternatively, other scale imprint lithography techniques may be used, such as micro-imprint lithography. **FIG. 2** illustrates one embodiment of an imprinting system 200 that includes imprint or die assembly 210, heater ~~assembly~~ 230, heat tunnel 240, disk substrate cooling ~~station~~tray 250, and disk cassette 260 mounted to table 201. Assembly 200 also includes a disk substrate transporting device 220 disposed next to table 201. In one embodiment, transporting device 220 may be a vacuum chuck coupled to a robotic arm that extends over table 201. Imprint assembly 210 includes upper die assembly 212 and lower die assembly 214 that may include one or more embossing foils (a.k.a., stamper) that press into an embossable film disposed above a disk substrate to transfer a pattern into the embossable film. Heater 230 having heating element 232 may be used to pre-heat the embossable film on the disk substrate to a desired embossing temperature. Heating element 232 may also extend along a length of top and bottom portions 242, 244 that form heat tunnel 240. In one embodiment, heater 230 and heating element 232 may have separate heating sources. In an alternative embodiment, heater 230 and heating element 232 may share the same heating source. In one embodiment, heating element 232 may

be heat coils utilizing inductive heating to maintain the temperature of the embossable film. In alternative embodiments, heat element 232 may be another type of element, for example, an infrared (IR) heat source. In one embodiment, a heat tunnel connects heater 230 with die assembly 210 in order to maintain the desired embossing temperature during transport of the disk substrate from heater 230 to die assembly 210.

[0035] The use of heat tunnel 240 minimizes thermal dissipation of the heated embossable film of the disk substrate. Thermal dissipation may lead to inconsistencies in the embossable film and subsequent inconsistencies in the embossed pattern. As discussed above, heat tunnel 240 maintains the approximate embossing temperature of the heated embossable film until the disk substrate is placed in the die assembly. Although the embossing foils in die assembly 210 may be heated, a heated embossable film may result in a quicker and more efficient imprint. Moreover, by positioning heater ~~assembly~~ [[280]]230 relatively close to die assembly 210, thermal distortion of the embossable film is minimized.

[0039] In one method for imprinting the embossable film disposed on disk substrates, robotic arm assembly 440 transports a disk substrate from cassette 460 and places it on a ~~disk holder plate~~servo slide tray 430 of infeed/outfeed assembly 420. Robotic arm assembly 440 includes link arm 442 coupled to one end of upper arm 444 to allow for full rotational movement around table 401. Assembly 400 has the ability to impart thermal qualities to the handling of disk substrates. The embossable film disposed above a disk substrate may be pre-heated to bring up the temperature of the embossable film on the disk substrate to an optimum embossing level. ~~Disk holder plate~~Servo slide tray 430 may be positioned within heater assembly 480 to heat the embossable film to an optimum embossing temperature. In one embodiment, the embossable

film disposed above a disk substrate may be heated to a temperature in the range of approximately 20 to 350 degrees C.

[0042] **FIG. 4A** illustrates an enlarged view of die assembly 410, visual assembly 470, and heater assembly 480 of assembly 400. In one embodiment, heater assembly 480 includes a stand 486 that positions a heater box portion 481 at a height level with die assembly 410 and between top die 402 and bottom die 404. Box portion 481 includes an opening 484 to receive ~~disk holder tray~~servo slide tray 430, and well as an opening 482 near a top surface to allow a line of sight for microscope 472 of visual assembly 470. In one embodiment, opening 482 may be covered with transparent glass. Bracket 474 allows microscope 472 to be positioned above box portion 481.

[0045] Infeed/outfeed assembly 520 includes a first slider 522, a second slider 524 disposed above and perpendicular to first slider 522, ~~flex supports~~flexures 526, 528 extending from second slider 524, and holder plate 530 disposed near and end portion of ~~flex supports~~flexures 526, 528. In one embodiment, first and second sliders 522, 524 form a X-Y servo slide mechanism. Holder plate 530 is configured to receive a disk substrate (e.g., disk ~~substrates 550, 551~~substrate 550). In one embodiment, palm extension 548 may hold to disk substrates at one time. Visual unit 570 may be positioned between imprint assembly 510 and infeed/outfeed assembly 520. Bracket 574 is mounted to table [[521]]501, with microscope 572 coupled to a top portion of bracket 574.

[0046] **FIG. 5A** illustrates one end of palm extension 548 positioning disk substrate [[551]]550 in holder plate 530. **FIG. 5B** illustrates holder plate 530 positioned between upper

die assembly 502 and lower die assembly 504 of imprint assembly 510. Second slider 524 slides along rails on first slider 522 to advance holder plate 530 towards imprint assembly 510. The palm extension 548 returns to cassette 560 to retrieve additional disk substrates. Alternatively, robotic arm 540 may also be used to retrieve a disk substrate after it has been imprinted with imprint assembly 510. Visual assembly 570 may be used to check for proper alignment of the imprinting foils on the disk substrate. The proper alignment for a disk substrate may be achieved by the X-Y servo mechanism of infeed/outfeed assembly 520. In one embodiment, a vision assembly inspects a disk substrate after an embossing procedure to check for proper alignment with respect to a disk substrate center. The disk substrate is retracted from the imprint assembly and positioned to a known reference point directly below a microscope or an optical device (e.g., camera). The pattern printed on the disk is then examined. If it is found that the imprinted pattern is offset, instructions may be forwarded to the infeed/outfeed assembly to shift the holder plate to the proper position via the X-Y servo slide. This permits future disk substrates to be aligned properly with the embossing foils.

[0047] **FIG. 6** illustrates one embodiment of a die assembly 600. In one embodiment, die assembly 600 may be the same as the die assemblies discussed above with respect to **FIGS. 2**, **3**, and **4**. An upper portion of imprint assembly 600 includes top cross beam 620, upper die assembly 602, lower die assembly 604, and press baseplate 606. Upper die assembly 602 and lower die assembly 600 are coupled by posts 610, 611, 612, and 613. The base portion of each post has a bushing (e.g., bushings 614, 615, 616, and 617). Upper die assembly 602 also includes upper holder 640 for mounting an upper imprinting foil 650. Lower die assembly 604 includes lower holder 642 for mounting a lower imprinting foil (not shown). Lower holder 642

is disposed above lower holder base 646, ~~floater~~float plate 647, and baseplate 648. Upper and lower die assemblies 602, 604 are disposed above press base plate 606.

[0049] **FIG. 7** illustrates one embodiment of an enlarged view of the top portion of imprint assembly 600. Top support 603 of top die assembly 602 is substantially similar in size and shape with lower support 605 of lower die assembly 604. Posts 610, 611, 612, and 613 are disposed near the corners of the rectangular shaped top and lower supports. Each of the posts have a cylindrical shape having an outer diameter that is slightly less than an inner diameter of each of the bushings (e.g., 614, 615, 616, and 617) to allow upper die assembly 602 to move down towards lower die assembly 604. Upper holder 640 is coupled near a central portion of top support 603. As discussed above, lower holder 642 is disposed above base 646, float plate 647, and baseplate 648. A number of pressure nozzles (e.g., 670[[, 671]]) secure float plate 647 to baseplate 648. Screws mounted on each of the pressure nozzles allow for adjustments of the ~~flow~~float plate 647 with respect to the baseplate 648 to align lower holder 642 with upper holder 640 properly. This may be necessary when adjustments are made to align lower embossing foil 651 with upper imprinting foil (not shown). As such, imprint assembly 600 allows for movement of top die assembly 602 towards lower die assembly 604 with the four posts mounted near the corners of top and lower supports. Lower holder 642 may be moved or adjusted laterally to align itself with upper holder 640 properly.

[0050] **FIGS. 7A – 7B** illustrate cross-sectional views of one embodiment of upper die assembly 602 and lower die assembly 604. A bottom embossing foil 651 is disposed above a press pad 680 of lower die assembly 604. In one embodiment, press pad 680 may include be one or more elastomeric layers 681, 682 that allow for a uniform press of ~~embossing~~bottom foil 651

against the embossable film of disk substrate 650. A central rod 684 extends through a center portion of lower die assembly 604 and is coupled to spring 685. Central rod 684 has a tip portion 686 that is a tapered mandrel and exposed above press pad 680 and ~~embossing~~bottom foil 651. Tip portion 686 is tapered to fit inside the inner diameter (ID) of bottom foil 651 as well as disk substrate 650. A linear ball bushing 688 surrounds the elongated portion of central rod 684, and an outer sleeve 690 surrounds linear ball bushing [[618]]688. A ring portion 692 is disposed between outer sleeve 690 and tapered portion 686 of central rod 684. Ring portion 692 is also in contact with an ID of ~~embossing~~bottom foil 651. A portion of the inner diameter of bottom foil [[614]]651 extends downward and is disposed between lower mandrel [[612]]686 and outer sleeve [[620]]690.

[0052] **FIG. 8** illustrates an enlarged view of a disk transporting device in the form of infeed/outfeed assembly 700 without the slider portions. A holder plate 704 is disposed on frame 702. A disk substrate 750 is secured to holder plate 704 with center finger 706, first side finger 708, and second side finger 710 radially disposed around disk substrate 750. In one embodiment, the fingers may be linked together and supported by a series of flexure joints. A pair of cantilevered flexures 712, 714, support frame 702 and are also coupled to baseplate 726. Flexures 712, 714 allow holder plate 704 to move up and down when placed within the imprint assembly (e.g., imprint assemblies 410, 510 described above with respect to **FIGS. 4**, **4A**, **5A**, and **5B**). Holder plate 704 may also be supported by fixed supports 716, 718. These supports are rigid to provide stiffness and support the weight of frame 702. Top lifts 720, [[722]]724 couple fixed supports 716, 718 to base plate 726. One side of frame 702 also includes a bracket 722 that has an opening to receive a thrusting actuator to rotate the flexure joints of center finger

706, first side finger 708, and second side finger 710. As described in greater detail below, the thrusting actuator allows for a disk substrate to be captured repeatedly in the exact same position.

[0055] **FIG. 11** illustrates an alternative embodiment of clamping or gripping structure 900 that may be embedded within a plate holder. Gripper 900 does not require a thrusting actuator but has an outer ring that includes a series of joints 920, 922, and [[944]]924 that connect fingers 912, 914, and 916. Each of the fingers has extensions 912, 914, and 916 that are configured to make contact with an outer diameter of a disk substrate. Each of the joints are flexible to allow the fingers to expand outward or pivot to receive a disk and then compress to make contact with the disk. **FIG. 12** illustrates one embodiment of gripper 900 embedded within holder plate 904 and clamping disk substrate 950. Joints 920, 922, and [[944]]924 have expanded outward to receive disk substrate 950. Extensions 912, 914, and 916 of fingers 906, 908, and 910 respectively make contact with an outer diameter 952 of disk substrate 950.

[0056] **FIGS. 13A**, **13B**, and **13C** illustrate embodiments of a method of imprinting an embossable film disposed above a substrate. An embossable film disposed above a substrate (e.g., a disk substrate) is pre-heated, for example, to an embossing temperature, step 1005. The embossable substrate may be pre-heated in an oven (e.g., ~~oven~~heater 330) designed to receive the substrate. In one embodiment, the substrate is then transported through a heat tunnel (e.g., heat tunnel 240) to a die assembly, step 1010. Once placed in the die assembly, the substrate is centered or aligned relative to an embossing foil (e.g., embossing foil 651) disposed within the die assembly, step 1015, followed by imprinting, step 1020. The imprint pattern on the embossable film of the substrate may then be inspected, step 1025, and then cooled, step 1030.

[0059] As previously mentioned, the apparatus and methods discussed above may be used for the imprinting of an embossable film disposed above a base structure of a disk. Referring to **FIG. 14A**, the base structure [[1110]]1100 of a disk may be composed of a substrate 1115 and a plated NiP layer 1120. Substrate 1115 may be manufactured from, for examples, a glass or metal/metal alloy material. Glass substrates that may be used include, for example, a silica containing glass such as borosilicate glass and aluminosilicate glass. Metal alloy substrates that may be used include, for example, aluminum-magnesium (AlMg) substrates. In an alternative embodiment, other substrate materials including polymers and ceramics may be used.

[0061] In an alternative embodiment, base structure [[1110]]1100 may be composed of a substrate 1115 having other layers disposed thereon, for examples, a soft magnetic film. ~~Layer~~NiP layer 1120 may represent a soft magnetic film or a soft magnetic film disposed over a NiP layer. A soft magnetic film may be used to achieve the proper magnetic properties associated with perpendicular magnetic recording. The soft magnetic film may be a layer of iron-cobalt-nickel (FeCoNi) material. Other materials that may be used for the soft magnetic film include cobalt-iron (CoFe) nickel-iron (NiFe), and alloys thereof. Soft magnetic films and materials that may be used for manufacturing a soft magnetic film are well known in the art of magnetic recording disks; accordingly, a detailed discussion is not provided. The soft magnetic film may be polished and/or textured. The soft magnetic film may be textured with a pattern, by various methods such as mechanical texturing using fixed or free abrasive particles (e.g., diamond). Alternatively, other types of texturing methods, such as laser texturing, may be used to texture the soft magnetic film. In yet another embodiment, a thin NiP layer may be disposed on top of the soft magnetic film and polished and/or textured. In yet another embodiment, the

soft magnetic film may be composed of one or more soft magnetic underlayers and one or more Ru interlayers disposed between soft magnetic underlayers.

[0062] Embossable film 1130 is disposed on the base structure [[1110]]<u>1100</u> in order to form an imprintable (i.e., embossable) film. Various embossable materials may be used to form the embossable film 1130. In one embodiment, for example, poly(methyl methacrylate) (PMMA) or a co-polymer - poly(methyl methacrylate methacrylic acid copolymer) (P(MMA-MAA) may be used for embossable film 1130. Alternatively, other embossable materials may be used for example, PMMA and a thermo-set polymer such as MR-I 9000 available from Micro Resists Technology of Germany. Alternatively, embossable film 1130 may be composed of multiple embossable films. The embossable materials may be spin coated on base structure [[1110]]<u>1100</u> to produce the embossable film 1130. Other coating methods such as dip coating, dip-spin coating, spray coating, sputtering and vacuum deposition (e.g., CVD) may be used.

[0063] **FIGS. 14A**, **14B**, **15A**, **15B** and **15C** illustrate alternative embodiments of a method of imprinting an embossable film such as an embossable film disposed above a base structure. In one embodiment, the base structure may be a substrate or a disk substrate. Embossable film 1130 is disposed over base structure [[1115]]<u>1100</u>, step 1210. In one embodiment, embossable film 1130/base structure [[1115]]<u>1100</u> and stamper 1190 are heated at or above the "glass transition temperature" (Tg) of embossable film 1130, step 1230. The glass transition temperature is a term of art that refers to the temperature where a polymer material becomes viscoelastic above this temperature (which is different for each polymer).

[0066] **FIG. 15C** illustrates an alternative embodiment of imprinting an embossable film including preheating the embossable film prior to imprinting. In this embodiment, embossable film 1130 and stamper 1190 may be separately heated. In step 1212, after disposing embossable film 1130 over the base structure, this structure may be preheated to the embossing temperature prior its introduction into die assembly [[230]]<u>210</u> by, for example, heater 230 of **FIG. 2**. In step 1214, the preheated embossable film 1130/base structure [[1115]]<u>1100</u> is positioned in close proximity (e.g., nest area of lower die assembly 214) to the stamper 1190. Alternatively, the embossable film 1130/base structure [[1115]]<u>1100</u> may be preheated to a temperature below that of (e.g., close to) the embossing temperature and then heated to the embossing temperature during or after its positioning in the nest area of lower die assembly 214. Alternatively, the embossable film 1130/base structure 1115 may be preheated to the stamper's temperature/embossing temperature and imprinted after its close positioning to stamper 1190. Stamper 1190 is then pressed into the embossable film 1130 at the embossing temperature, step 1230. The stamper 1190 is then separated from embossable film 1130 after imprinting, step 1240. In one embodiment, the embossable film 1130/base structure [[1115]]<u>1100</u> may be removed from close proximity to stamper 1190, step 1241, and then cooled to a temperature below the glass transition temperature of embossable film 1130. The stamper 1190 is then separated from embossable film 1130 after imprinting. In one embodiment, the embossable film 1130/base structure [[1115]]<u>1100</u> may be removed from close proximity to stamper 1190 and then cooled to a temperature below the glass transition temperature of embossable film 1130, step 1243.

[0067] An imprinted pattern of trenches areas (a.k.a., recessed areas, grooves, valleys, etc.) and plateaus (a.k.a., raised areas) is thereby formed in the embossable film [[1230]]<u>1130</u> (as

illustrated in **FIG. 14B**). Following the imprinting of a pattern into embossable film 1130, a subtractive or an additive process may be used to form the desired DTR pattern in the disk. In a subtractive process, for example, one or more layers disposed above the substrate 1115 may be removed (e.g., through imprint lithography and etching) to expose a desired pattern on layer 1120 (e.g., a NiP or soft magnetic layer). Alternatively, the DTR pattern may be formed in substrate 1115. In an additive process where layer 1120 is, for example, a NiP layer, a material compatible or identical to material forming the initial NiP layer is added or plated to form the raised areas [[1110]] of the discrete track recording pattern.